23 ECONOMIC VALUE OF WILDLIFE RESOURCES IN THE SAN JOAQUIN VALLEY: HUNTING AND VIEWING VALUES

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ABSTRACT

This chapter quantifies the effects of agricultural drainage on the recreational demand for wildlife resources in the San Joaquin Valley (Valley). The current value of waterfowl hunting is $3.2 million annually at public refuges and $16.5 million for the entire Valley. The value of viewing birds in the Valley is $64.7 million annually. An estimate of the change in waterfowl hunting benefits at Kesterson National Wildlife Refuge (NWR) resulting from control of agricultural drainage water is made by combining information on wildlife response to selenium with a quality differentiated demand equation for waterfowl hunting. This simulation illustrates how a bioeconomic analysis of waterfowl hunting benefits from reducing wildlife contamination can be performed.

INTRODUCTION

Wildlife have a variety of values. They have ecological values for other species of animals and plants and for the communities in which they dwell. They also have ecological and economic values for society at large. Recreational demand for wildlife is often the largest portion of the total economic value of wildlife. This chapter examines the effects of agricultural drainage as a wetland water supply on the recreational demand for wildlife resources in the Valley. An estimate of the change in waterfowl hunting benefits resulting from a change in the level of drainage is made by combining the methodology and results of studies done on the recreational demand for Valley wildlife with what is known about the effects of drainage on the wildlife populations.

This study focuses on the onsite recreational demand for wildlife. Waterfowl hunting and bird viewing are the primary onsite recreational uses of Valley wildlife that are affected by agricultural drainage and which have been exam-

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ined in an economic context. The economic value to society from preserving wildlife in the Valley has recently been performed by Loomis et al. in another chapter of this volume.

CONCEPTS OF ECONOMIC VALUE OF WILDLIFE

Unlike most commercial goods, wildlife species in the Valley are largely nonmarket environmental resources. Hence, the economic value of the wildlife is not readily apparent. A nonmarket good, as opposed to a market good, is one which is not readily traded on the open market. The dollar value of a market good, a packaged frozen fryer for example, is readily determined: it is the dollar value - determined through the interaction of the forces of supply and demand - charged for the good in the local grocery store. On the other hand, waterfowl taken in a wildlife refuge are nonmarket goods. The payment the hunter must make to use a public area is the cost of the hunting application. This payment, or fee, is administratively set by the Government, frequently with little consideration for the interaction of supply and demand for the animal. Hence, the fee is not a market-clearing price (i.e., the price at which the supply equals the demand for the good). To make an estimate of what the market-clearing price would be if there was a market for the good, some sort of nonmarket resource valuation techniques are needed. Possible techniques to measure economic values of recreation include the Hedonic Price Approach, the Contingent Valuation Method (CVM), and the Travel Cost Method (TCM).

In addition to economic values of onsite recreation use and commercial uses of wildlife, there are many offsite user values. These include option, existence, and bequest values, all of which can be held by the general population as well as recreationists. Option value can be thought of as an insurance premium people would pay to insure availability of wildlife recreation opportunities in the future. Existence value is the economic benefit received from simply knowing wildlife exist. Bequest value is the willingness to pay (WTP) for providing wildlife resources to future generations. While option and existence values may be present for manufactured consumer goods, Randall and Stoll (1983) claim those values are likely to be empirically insignificant in size compared with the value of certain scarce wildlife species. Since the focus of this chapter is recreation, offsite values are not quantified here. However, offsite values can be estimated through survey techniques such as the CVM, as discussed for the Valley in the chapter by Loomis et al.

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To clarify the discussion of the economic benefits of hunting and viewing wildlife, several terms will be defined in this section.

Economic value is measured in terms of the consumer's net willingness to pay. Consumer surplus is the economist's term for the consumer's net willingness to pay, which is the maximum increase in price above current costs a person would be willing to pay to purchase a good or service. Consumer surplus represents the consumer's additional (net) willingness to pay for the opportunity to, for example, hunt at some specific site. It is net or additional willingness to pay beyond current expenditures. Examples of a "good or service" as related to wildlife would be a waterfowl hunting trip or the experience of viewing wild birds. Total or gross willingness to pay is the sum of net willingness to pay and the amount actually spent on the good. Since the amount actually spent is part of the cost of participation, the benefits (i.e., the net willingness to pay) are just the amount in excess of what people spend.

It has been suggested (U.S. Water Resources Council, 1983 and U.S. Department of the Interior, 1986) that economic values lost to society be measured in terms of net willingness to pay in assessing natural resource damage and mitigation measures. The net willingness-to-pay criteria has also been broadly used in textbooks on Benefit Cost Analyses (Sassone and Schaffer, 1978; Just, Hueth, and Schmitz, 1982).

The CVM and the TCM are the dominant methodologies used in estimating the recreational value of wildlife resources. CVM is sometimes referred to as "the bidding method." In essence, a hypothetical but realistic market is established for some type of nonmarket good, say a recreational trip to a particular site. In open-ended questions, the respondent is asked to specify the maximum amount he or she would pay for that trip, including access and use fees. In close-ended (or dichotomous choice) questions, the respondent is asked whether he or she would pay some amount stated in the question. This dollar amount varies from individual to individual. By evaluating the probability of the respondent stating "Yes I would pay the [specific dollar amount]," an expected value of willingness to pay can be computed. For a thorough discussion of the strengths and weaknesses of the CVM see Schulze et al. (1981) or Cummings et al. (1986, and this volume).

Research on the accuracy of CVM has been performed by Welsh (1986), who bought and sold 1-day deer hunting tags for the Sandhill Demonstration area. Two parallel markets were established: (1) A real market where the hunters surveyed could actually buy the deer tags for real money and (2) a CVM survey of hunters, identical to (1) with the exception that no cash changed hands. Comparison of the results from the two markets showed that CVM yielded a value 25 percent higher than the actual cash value of the deer hunting tag.

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Loomis (1989) tested the reliability of the CVM using the test-retest approach. In surveys of both visitors and the general public, willingness to pay responses were not statistically different between the first survey and the second survey 9 months later.

The TCM statistically traces out a demand equation, using observations of travel distance as a measure of price and number of trips taken as a measure of quantity. The resulting first stage, or per capita demand equation allows the calculation of the additional amount a recreationist would pay over travel costs (i.e., consumer surplus) to have access to a particular wildlife site for viewing, hunting, or fishing. This calculation is made using a "second stage," or site, demand curve that relates added distance or added travel cost of, for example, trips to a particular hunting area. See Clawson and Knetsch (1966); Dwyer, Kelly, and Bowes (1977); Sorg and Loomis (1985); or Ward and Loomis (1986) for a discussion of the basic TCM approach.

IMPORTANCE OF WILDLIFE RESOURCES IN THE SAN JOAQUIN VALLEY

Waterfowl Hunting Statistics for the Valley

Table 1 presents waterfowl hunting statistics for California counties in the Valley for the years 1983 through 1985. Waterfowl considered include ducks, geese, and coots, which together form the vast majority of the waterfowl species hunted in the Valley. The table aggregates California Department of Fish and Game (DFG) data (various years) for San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Tulare, and Kern Counties, which comprise the geographical area of the Valley.

Table 1. Waterfowl hunting use for the San Joaquin Valley (includes hunting on both public and private lands).

Year	*Take*	*Hunters*	*Hunter-days*
1985	468,508	37,779	265,727
1984	445,184	40,212	255,816
1983	567,226	39,100	308,016
1982	501,688	36,603	NA

Reports for years prior to 1
only 1982 is included here.
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Wildlife Viewing Statistics

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	Hunter-days
	265,727
	255,816
	308,016
	NA

Reports for years prior to 1983 do not present the hunter-days by county, and only 1982 is included here. Although the table exhibits a great deal of variability, hunter take and hunter days have exhibited a downward trend over the last few years. By the October 1987 through January 1988 hunting season (not included in table 1), only 27,603 hunters were recorded at the seven public refuges in the Valley.

Wildlife Viewing Statistics

A mail survey of 3,000 randomly selected California households conducted in 1987 provided the data for the analysis. The survey was conducted by the University of California, Davis, using a population-weighted sample drawn by a professional survey research firm (Survey Sampling, Inc.). The survey asked questions about viewing birds and deer in California. After deleting the undeliverable questionnaires, the overall response rate to this survey was 44 percent. While a higher response rate would have been desirable, this response rate is acceptable and believed to be representative of Californians with focused interest in wildlife. It is equal to or greater than the response rates for similar CVM surveys conducted in California over the last few years.

The respondents, each representing a California household, were requested to answer questions on whether they saw any wild birds on any outdoor recreation trips during the 12 months prior to the date of the survey. Table 2 presents the summary statistics on all outdoor recreation trips taken in the Valley during 1987 for the primary purpose of viewing birds. Table 2 also presents the summary statistics for general purpose outdoor recreation trips taken in the Valley during 1987 in which the respondents viewed birds. This category includes the data on trips both for the primary purpose of viewing birds plus trips for all other recreational pursuits.

Table 2 is organized by county. Sample size is the total number of surveys returned specifying Valley counties as the trip destination. The table presents the total number of trips to each county and the sum of all trips to the region. Note that for primary purpose trips, data were available for only the Valley counties of San Joaquin, Merced, and Fresno.

Because only a percentage of the total California households were sampled, the data on trips must be expanded to an equivalent Statewide use level. The estimated total trips in table 2 expands the trips per region to account for the difference between the actual population size of California and the size of the sample.

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Table 2. Estimated total general purpose recreational trips during which wild birds were seen and estimated total trips for the primary purpose of viewing birds by Californians in 1987.

	Primary purpose trips	*Sample size*	*General purpose trips*	*Sample size*
San Joaquin	23,430	3	487,344	8
Stanislaus			159,324	8
Merced	166,353	4	185,097	5
Madera			107,778	7
Fresno	23,430	2	149,952	13
Kings			65,604	5
Tulare			318,648	34
Kern			260,073	15
Total	213,213	9	1,733,820	95

Data source: Nonconsumptive Wildlife Use Bird Survey.
Note: Primary purpose trips data are available for only three Valley counties.

APPLICATION TO SAN JOAQUIN VALLEY

Benefits of Bird Viewing

The same survey used to estimate the number of bird viewing trips to the Valley was also used to estimate the willingness to pay for the experience of viewing wild birds. Close-ended CVM questions were used to estimate trip values.

Specifically, the average cost and the maximum willingness to pay for the most recent trip were estimated for all Californians. The respondents were asked: (1) What their approximate costs were for transportation, food, and lodging on their most recent trip when they saw wild birds and (2) if their annual expenses where $X higher, would they still visit that site?

Unfortunately, the sample for the Central and San Joaquin Valley counties is so small that no reliable inferences can be made about the value of viewing birds in this specific California region. Hence, the overall results for California must serve as a proxy for the San Joaquin Valley values.

The specific question asked is, "If your annual cost of visiting just this area [the area of the most recent trip where wild birds were seen] increased by $X

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General purpose trips	Sample size
487,344	8
159,324	8
185,097	5
107,778	7
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65,604	5
318,648	34
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would you still visit the site?" The $X amount is the bid amount written into each survey.

With close-ended willingness-to-pay questions, the calculation of expected willingness-to-pay is a two-step process. In the first step, a logistic regression, which is equivalent to an inverse demand function, is estimated with probability of a "Yes would pay $X" response as the dependent variable and the amount ($X) as the independent variable. The logit model is an econometric model in which the statistical equation has a limited dependent variable, i.e., the dependent, or left-hand side variable, consists only of zeros and ones. If a "yes" is assigned a value of 1 and a "no" a value of 0, the logit model can be used to perform regressions on willingness to pay questions that require a dichotomous "yes" or "no" answer. Once this logit curve is estimated, the area under that curve, which is the expected willingness-to-pay, is calculated. The area under a logit regression function is estimated by integration of the function. The vertical axis of this two-dimensional area is the probability that a particular increase in trip cost would be paid by the respondent.

The constant and the slope, or log of the bid amount, are entered in an integration program, which then calculates the expected value, or average willingness-to-pay for a trip, under each of three conditions: (1) Current conditions; (2) 1.5 times more birds seen than under the current conditions; and (3) twice as many birds seen.

The estimated model is

[1] BCRPAY=f (BID, BIFL, INC, BSEEN, TRIPS)

where: BCRPAY is the dichotomous answer.

BCRPAY= O no, will not visit the site.
1 yes, will visit the site.

BID is the dollar amount of increased annual trip cost the outdoor recreationist was asked to pay to visit the most recent site visited where wild birds were seen.

INC is the recreationist's annual household income ($).

TRIPS is the number of recreational trips to the most recent area visited where wild birds were seen.

BSEEN is the number of birds seen during the receationist's most recent trip.

BIFL is the influence that the potential of seeing wildbirds at a site has on the choice of what sites to visit.

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Table 3. Logit equation for maintenance of current conditions.

Variable[a]	*Coefficient*	*t-Statistic*	*Mean All*[b]
Constant	-1.4734	-0.95023	1
Bid	-8.8507	-8.1408	$30.22
Bird influence	0.7495	2.7146	1.41
Income	0.4039	2.8310	$36,791.00
Birds seen	0.2926	3.2388	28.43
Trips	-0.03616	-0.3425	3.04

Note: 370 Cases where BCRPAY = 1; 163 Cases where BCRPAY = 0
[a]Note: the independent variables are in natural log form in the regression.
[b]Note: means are of the untransformed variables.

Table 4 presents the willingness-to-pay estimates for the three potential levels of bird viewing. Since the number of birds seen was found to be positively related to willingness-to-pay, it is possible to calculate how WTP changes if the number of birds to be seen was increased. As the results indicate, the respondents are willing to pay more to see more birds.

As shown in table 4, trip benefits (economic values) do increase with the number of birds to be seen. However, the principle of diminishing marginal returns is evident here: each additional bird seen adds less additional enjoyment than the previous bird seen. For example, trip enjoyment increases by approximately $0.50 per additional bird seen up to a 50-percent increase and then about $0.20 more per bird up to double the population (100 percent more birds). Since each bird seen is a public good available for all the visitors to view, if there are 1,000 visitors a day viewing birds over a 10- to 20-day period, the aggregate benefits of additional birds could be several thousand dollars.

Table 4. Willingness to pay estimates for viewing birds in California under three different scenarios.

	Annual Total WTP	*Avg. No. of Trips Per Year*	*Net WTP Per Trip*	*No. Birds Seen Per Trip*
Current conditions	$112.00	3	$37.33	28
50% more birds	135.00	3	45.00	42
100% more birds	140.00	3	46.67	56

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t-Statistic	Mean All[b]
-0.95023	1
-8.1408	$30.22
2.7146	1.41
2.8310	$36,791.00
3.2388	28.43
-0.3425	3.04

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Net WTP Per Trip	No. Birds Seen Per Trip
$37.33	28
45.00	42
46.67	56

The estimated value of viewing birds is based on the total number of recreational trips in the Valley in which birds were seen. This number is 1,733,820 trips (table 2); total value per trip is $37.33. The total annual value for bird viewing in the Valley is then $64,723,500. Since data on trips for the primary purpose of viewing birds exist for only three Valley counties, an estimate of the total annual value of Valley trips for the primary purpose of viewing birds cannot be made.

Demand for and Benefits of Waterfowl Hunting

Using hunter application data, TCM demand curves were estimated and net willingness-to-pay calculated for waterfowl hunting in Valley refuges for the 1987-88 hunting season. During the October 1987 through January 1988 hunting season, 27,603 hunters visited these seven refuges.

To estimate the demand for waterfowl hunting, a variation of the usual TCM model was estimated. The traditional TCM demand equation uses trips per capita from a given zone (e.g., county) of origin to a particular site as its dependent variable. However, one of the assumptions of TCM is that all recreationists at any given distance are able to visit as frequently as they desire. That is, observed visitation rates are supposed to reflect the desired level of consumption given the travel cost facing the hunter (Dwyer, Kelly, and Bowes, 1977). However, in the case of waterfowl hunting in the Central Valley and San Joaquin Valley refuges, there is excess demand for permits. As a result not all hunters desiring to go waterfowl hunting in the refuges at the current permit and travel price are allowed to do so. The excess demand is rationed by the California DFG by means of a lottery. As an approach to account for the real, underlying demand (rather than just that portion of demand actually realized as an outcome of the lottery) applications per capita is used rather than trips per capita as the dependent variable. Applications reflect the participation level that waterfowl hunters desire at current permit and travel prices. Thus, use of applications meets the assumptions of the TCM whereas trips, in this case, would not. For more details see Loomis, 1982.

In addition to the seven Valley refuges (listed in table 5), the data set for the TCM regression included five Central Valley refuges (Colusa, Delevan, Gray Lodge, Sacramento, Sutter). The estimated model is :

$$[2]\quad \ln(APPLICATONS_{ij}/POP_i) = \underset{(-7.77)}{-24.277} - \underset{(-15.25)}{1.406}[\ln(TWOWYDIST_{ij})]$$

$$+ \underset{(2.53)}{0.235}[\ln(HVST_j)] + \underset{(2.33)}{0.733}[\ln(AVINCOME_i)] + \underset{(9.96)}{1.301}[\ln(WATER_j)],$$

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$R^2 = 0.607$, $F = 102.23$, observations = 270.
Numbers in parenthesis are t-values

where,

APPLICATIONS/POP is the per-capita number of applications

TWOWYDIST is the two-way trip distance from the hunter's resident county i to the refuge. This variable is the price (in terms of distance traveled) of visiting a refuge.

HVST is the average of the monthly total waterfowl harvest in the previous season, i.e., in the 1986 season.

AVINCOME is average hunter income.

WATER is total water supplied (acre-feet) to the refuge's wetlands during the hunting season. This variable is a proxy for the amount of waterfowl habitat at a refuge.

The R^2 is quite high for a cross-sectional TCM regression. In addition, all the coefficients are of the expected sign, and all are significant at the 5-percent level or higher.

The equation was estimated in the double-log form for a number of reasons. The most important reason for choosing a log model is that past research has shown that taking the natural log of the applications per capita minimizes two problems that arise with a linear model. First, with the log model the possibility of predicting negative applications per capita from distant counties is eliminated. Second, heteroskedasticity associated with zones of different population sizes is minimized using the log of the dependent variable (Strong, 1983 and Vaughan et al., 1982). The double-log model was selected over the semilog form as it provided a better statistical fit to the data. Because the model is estimated in double-log form, the coefficients are elasticities. Except for the coefficients on distance and total water use, all the elasticities are inelastic.

From the per-capita demand equation, each site's second stage demand curve was calculated. Because the price variable in the per-capita demand equations is scaled in terms of miles instead of dollars, the area under the second stage demand curve represents willingness to "pay" by traveling additional miles. In order to calculate net economic values in dollars, the hunter's additional willingness to "pay" by traveling additional miles must be converted to willingness-to-pay in dollars. This involves multiplying the added distance by a cost per mile. This travel cost per mile is the sum of two components: vehicle operating cost per mile and value of travel time.

Converting the added willingness-to-pay from miles into dollars follows the approach suggested in the U.S. Water Resource Council procedures (1979, 1983) of using (1) one-third the wage rate as the opportunity cost of travel time and (2) variable automobile costs. For a midsize vehicle, the variable transpor-

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tation costs per mile is \$.172 for fuel and repair costs (Hertz, 1986). To account for the likelihood that there is more than one hunter per vehicle and that each hunter in the vehicle will pay his or her share of the vehicle operating costs, the \$.172 per vehicle-mile is divided by the average number of hunters (passengers) per vehicle, which is assumed to be 2.41 hunters (Sorg, 1987).

The opportunity cost of travel time reflects the deterrent effect that longer drives have on visiting more distant sites, independent of the vehicle operation costs. For example, many higher income people could afford the extra \$8 of gasoline to drive an additional 2 hours, but could not "afford" the additional time cost in terms of other activities forgone. The hourly wage is used as a proxy for the opportunity cost of time. This is based in part on work by Cesario (1976), which demonstrated that the opportunity cost of time in commuting studies equaled between one-fourth and one-half the wage rate. In the current study, U.S. Water Resources Council Principles and Guidelines (1983) were followed, with the opportunity cost of time calculated as one-third of average wage rate. The calculated opportunity cost per mile is \$0.1282 for this data set. Total variable cost per mile per hunter is then \$0.1282 + \$0.172/2.41 = \$.20.

With the double-log model, trips can never fall to exactly zero. To be conservative, the top of the second stage demand curve was truncated at the maximum observed trip distance, which was 1,000 round-trip miles. The area under this curve starting at the base value and ending at a distance of 1,000 miles is the net willingness to pay, or the amount the sampled waterfowl hunters are willing to pay above the actual amount paid.

The total consumer surplus for each of the seven Valley sites is the product of that site's consumer surplus per hunter day and the total number of hunter days (U.S. Department of Interior, 1987) at that site. The sum of the total consumer surplus across all seven sites is \$3.2 million. Table 5 presents the consumer surplus per hunter day and the total consumer surplus per site for the San Joaquin NWR's and wildlife areas examined in the survey. As the demand equation [2] tends to underestimate total trips, the benefit estimates err on the conservative side.

From table 1, the total number of waterfowl hunting days in all private and public areas in the Valley is 265,727 (source: *Report of the Game Take Hunter Survey*, published annually by the California DFG.) If hunters at all wildlife areas are assumed to have a similar hunting experience as hunters at the public areas listed above, this figure can be multiplied by the average consumer surplus value of \$55.41, yielding a total annual value for waterfowl hunting of \$16,475,074. In the next section of this chapter, the model will be used to estimate how waterfowl hunting benefits change with water levels and contamination control.

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Table 5. Consumer surplus per hunter day and total consumers for the 1987-88 season for selected San Joaquin Valley wildlife areas.

Refuge	*Consumer Surplus per Hunter-Day*	*Hunter Days*	*Total Consumer Surplus*
Kesterson NWR	$37.19	3,900	$145,041
San Luis NWR	51.11	9,000	459,990
Merced NWR	43.46	1,700	73,882
Volta WA	60.01	3,500	210,035
Los Banos WA	62.98	3,500	220,430
Mendota WA	63.74	31,723	2,022,024
Kern NWR	69.36	1,300	90,168
	Average $55.41	Total 54,623	$3,221,570

EFFECTS OF AGRICULTURAL DRAINAGE ON THE ECONOMIC BENEFITS OF WATERFOWL HUNTING

The primary harm to wildlife in Valley refuges from agricultural drainage is associated with the high concentrations of selenium in much of the drainage water. Although selenium is a necessary nutrient for life, high concentrations have been implicated in waterfowl deformities and death. At Kesterson NWR, which used agricultural drainage as a major source of water supply, high selenium levels were lethal to a large percentage of the waterfowl population. In general, most of the refuges listed in table 5 now receive little agricultural drainage, and correspondingly, have nonlethal levels of selenium.

Ohlendorf (1989) estimated the frequency of embryotoxicity (dead or deformed embryos or chicks) attributable to selenium levels in nesting aquatic birds at the Kesterson refuge for the period 1983-85. In 1983 (the only year for which coot data is available), 64.4 percent of coot nests had one or more dead or deformed embryos or chicks. For the period 1983-85, an average of 34.9 percent of duck nests had one or more dead or deformed embryos or chicks. Estimated reductions in these death and deformity figures are used to determine the increase in waterfowl hunting benefits at Kesterson associated with reducing selenium concentrations to nonlethal levels. To do this, the 1986 waterfowl harvest data used to estimate equation [2] was separated into duck, geese, and coot components, which were 94.4 percent, 2.0 percent, and 3.6 percent of total 1986 harvest, respectively, for the Valley refuges (DFG, *1986 Waterfowl Hunting Season Report*). Using DFG-estimated 1989 breeding population data for the Valley refuges (1986 data were not used as data were not

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collected that year for coots), the percent of harvested ducks and coots bred in the Valley (geese do not breed there) is estimated. The above figures suggest that 11.5 percent of the total winter duck population and 3.9 percent of the total winter coot population are bred there. It is reasonable to assume, therefore, that of the ducks and coots harvested in Kesterson, 11.5 percent and 3.9 percent, respectively, were bred there.

Using the embryotoxicity figures listed above, the increase in the number of harvested ducks and coots bred at Kesterson attributable to decreasing selenium levels to nonlethal concentrations is calculated. Without factoring the possibility of compensatory mortality (due to a lack of information on its magnitude), it is assumed that the 64.4 percent of dead or deformed coot embryos or chicks and the 34.9 percent of dead or deformed duck embryos or chicks would have survived at nonlethal selenium concentrations. For want of more detailed embryo or chick mortality data, the dead or deformity percentages, which are the percentages of all nests with one or more dead or deformed embryos or chicks, are assumed to be the total death or deformity percentages for a clutch of eggs. This plus the preceding assumption may lead to a liberal estimate of the increase in native waterfowl population due to a decrease to nonlethal levels of the selenium concentration. On the other hand, no adjustment is made for the possible decrease in reproductive ability of waterfowl that inhabit the refuge in winter but breed somewhere else as no data exist on this topic.

Using the figures cited above, of the 509 waterfowl harvested in Kesterson in 1986, 51 ducks and 1 coot were estimated bred there. With a reduction in the selenium level to a nonlethal concentration, 538 waterfowl (a 5.7-percent increase) would have been harvested there. Substituting this harvest figure into equation [2], yields a 1.4-percent increase in Kesterson hunting applications. This percentage increase translates into an increase of 55 hunter days in the sample expansion of Kesterson hunter visitation figures from table 5. With this increase in hunter visitation, the total consumer surplus increases by $2,030. Assuming a 100-year horizon for this increased surplus and an 8-percent discount rate used by Federal water resources agencies, the present value of this increase in consumer surplus is $25,400. Note that this is the value only to waterfowl hunters visiting Kesterson. It is provided as an example of how the preceding valuation technique can be applied rather than as a definitive value.

An increase in the total economic benefits of bird viewing at Kesterson resulting from a decrease in selenium concentration to nonlethal levels should be added to this figure. A lack of Kesterson bird viewing data makes this addition difficult at this time. However, Loomis et al.'s chapter in this book quantifies the option and existence values to all members of society of Valley wetlands and of reducing Valley contamination.

CONCLUSIONS

The Valley is heavily used for waterfowl hunting and wildlife viewing. While these recreational activities at National wildlife refuges and State wildlife management areas are nonmarket goods, the economic values have been quantified in this chapter using the travel cost and the contingent valuation methods. Waterfowl hunting at the seven public refuges and wildlife areas is worth $3.2 million annually. This value was found to be statistically related to waterfowl take, which in turn can be impacted by habitat contamination. By linking reductions in contamination to increases in waterfowl breeding populations at Kesterson NWR, an estimate of added benefits to waterfowl hunters can be computed for reductions in contamination. The same basic linkages apply to estimating the added wildlife benefits to viewers, but lack of viewing data for Kesterson prevented such a calculation. However, the benefits to other members of society of wildlife throughout the Valley is quantified by Loomis et al., in a subsequent chapter of this book. Even though some values for Kesterson wildlife could not be quantified, this chapter demonstrated how recreational use related to wildlife could be quantified and linked to agricultural contamination issues. More precise estimates of the economic effects await better biological data of onsite and offsite contamination effects on migratory birds.

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